# *IB Internal Assessment : BEST PRACTICE*

## DESIGN

**Aspect 1 : Formulates a focused problem / research question and identifies the relevant variables.**

1. A 'focused problem/research question: This is a question describing the investigation and is usually written in the following form:

   To investigate / find the relationship between_______x______ and ________y_____.
   y will most likely be given in the experimental title.

   eg. To investigate the relationship between **the length of a pendulum** and **its time period of oscillation**.

2. Identifies the relevant variables

   One variable only for independent and dependent variables. Draw a table

| Independent | dependent | controlled |
|---|---|---|
| x | y | (include the obvious ones!) |

eg. dependent : time period of oscillation
independent: length of pendulum
controlled : mass of pendulum, gravitational field strength, (light string)

**Aspect 2 : Designs a method for the effective control of the variables.**

This refers to the manipulation of the independent variable and the attempt to maintain the controlled variables at a constant value.

1. It is best to start with a labelled diagram of the apparatus/set up, that can be referred to in the method.

2. Your method will usually be more clearly understood if you write it as a series of numbered instruction steps

   eg. 1. Set up the apparatus as shown in the diagram
   2. Place a 20g mass at a point 30cm from the fulcrum
   3. etc.

3. In the method, be quantitative where possible, eg. set up a cantilever of length 50 cm. Place the 50g mass at 40 cm mark. It does not matter if the method changes when the experiment is carried out.

4. Describe how you **measured** the independent and dependent variables and how you **varied** the independent variable. State the instruments you use to take the measurements you wrote down in aspect 1.

5. **Control of variables :** state how each controlled variable you wrote down in aspect 1 is kept constant. eg. the length between the supports is kept at 50.0cm.

## <u>Aspect 3</u> : Describe a method that allows for the collection of sufficient relevant

1. 'The definition of sufficient relevant data usually implies repeating readings' eg. measuring the time for a ball to roll a given distance down an inclined plane can be repeated a number of times and then an average determined.

   Similar to aspect 2 - give values eg. "repeat steps 1 - 5 for lengths of 30 cm, 20 cm, 10 cm, 5 cm" or "repeat for the following currents of 0.5A, 1.0A, 1.5A, 2.0A".

2. 'Describe a method that allows for collection of sufficient relevant data' . Describe such a method. If in reality insufficient time was available, this can be discussed in the evaluation.

3. There must be a minimum of five readings, but it is advisable to do at least seven if they are easily obtainable.
   These readings should be well spaced (use the full range that equipment allows)

   eg. in a pendulum experiment whose length can range between 10cm and 100cm, ten data points in a range of 70cm to 90cm would be inappropriate.

# Data Collection and Processing

**Aspect 1** : **records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant**

1. Within tables of quantitative data, columns should be clearly annotated with a heading, units and an indication of the uncertainty of measurement. (see below)

2. Significant digits in the data and the uncertainty in the data must be consistent. (see below).

3. 'One off' readings should be recorded with an associated error (see below)

4. Presentation is important! Use a ruler. No crossings out in tables – start again if you make a mistake! No calculations in the tables.

**Example**

I = 0.22 ± 0.02 A
t = 20.1 ± 0.2s

| l/cm<br>± 1 | V/V<br>± 0.1 | m/g | f/Hz<br>± 100 | T/°C<br>± 0.5 |
|---|---|---|---|---|
| 10 | 6.2 | 50 ± 1 | 2000 | 20.0 |
| 20 | 7.0 | 100 ± 2 | 3000 | 25.0 |
| | | 150 ± 3 | 4200 | |

**Aspect 2** : **Processes the quantitative raw data correctly**

1. This aspects involves

   - combining and manipulating raw data to determine the value of a physical quantity eg. adding, substracting, squaring, dividing
   - taking the average of several measurements
   - transforming data into a form suitable for graphical representation.

2. The raw and processed data may be shown in one table. One sample calculation on how the errors were processed must be presented.

3. If raw data can be plotted directly, then a best fit line and the gradient calculated would ensure a 'complete'.

4. Presentation is important! Use a ruler. No crossings out in table – start again if you make a mistake. Do not show calculations in table.

**Aspect 3 : Presents processed data appropriately and, where relevant, includes errors and uncertainties.**

1. (a) If data is combined and manipulated to determine the value of a physical quantity, then the uncertainties must be propagated and a final uncertainty determined eg c = 4400J/kg $^{o}$C ± 500

   (b) Error should only have one sig fig : 4400 ± 474 is wrong. Significance in answer and error should be the same: 4380 ± 500 is wrong!

2. Graphs must have suitable scales (1:1, 1:2 or 1:5 etc) with the data points occupying the whole graph paper.

3. The independent variable should be on the x axis

3. Label and unit on both axes

4. Plot error bars. If they are too small, state this on the graph

5. Draw best fit line, maximum gradient and minimum gradient.

6. Draw large gradient triangles for each of the above Δx and Δy should be at least half of x & y available.

7. Show gradient calculations for each.

8. If the graph is a curve, draw a smooth curve

## Conclusion & Evaluation

**Aspect 1 : states a conclusion, with justification, based on a reasonable interpretation of the data**

1. Error to one sig fig - round up answer appropriately eg. 249.8 ± 29 = 250 ± 30

2. When attempting to measure an already known and accepted value of a physical quantity, such as the charge on an electron, wavelength of laser light or acceleration due to gravity, two types of comment can be made.

(a) (experimental value) = 340 ± 50 J / kg $^{o}$C

(book value) = 385 J/kg $^{o}$C

the book value lies within the experimental range

**NB: literature value consulted should be fully referenced**

(b) (experimental value) = 340 ± 20 J/kg $^{o}$C

(book value) = 385 J/kg $^{o}$C

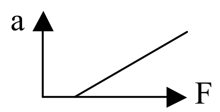
The book value lies outside the experimental range.

Nearest experimental value = 360 J/kg $^{o}$C

This is $\frac{25}{385}$ x 100 % = 6.5% **less** than book valve

3. If the conclusion is not quantitative, explanation should contain observations/trends revealed by data eg. A linear graph was obtained with a positive intercept on the y axis' or 'As y increases, x increases but with a decreasing gradient'.

4. In justifying your conclusion, you may comment on systematic errors encountered and the direction of the systematic error should be appreciated.
eg.




requires a comment

**Aspect 2 : Evaluates weaknesses and limitations**

1. Your evaluation ideally should address the reasons why your experimental value is ABOVE or BELOW the 'book value'.

2. Do not just list the weaknesses you must also comment on their significance in the experiment.

3. Limitations in the equipment must be discussed e.g in electron diffraction experiment there is a limited range of voltages for which the rings are visible.

4. From examiners

Candidates should critically appreciate limitations in their experimental results due to (i) assumptions in the theory (ii) experimental techniques and (iii) equipment used. The following examples have been given.

- If a V vs I graph does not form a linear and proportional line, it may be that the load resistance is changing as the I changes, so an ohmic relationship does not hold.
- Measuring the B field alongside a current carrying wire may confirm the inverse relationship, but for small distances and the largest distances the data does not line up. The induction coil has a finite size , and the centre of it is assumed to be zero. This may not be the case. At large distances, the radius is similar in magnitude to the length of the wire, and the inverse law for the B field assumes an infinite wire length.
- When using the sonic detector, the software was not calibrated with the speed of sound first, and so the measured distances were inaccurate. This error was due to an unexamined assumption, but it was appreciated when the experimental results were evaluated.
- The experiment was done to determine the efficiency of an electric motor. As the investigation was carried out, the battery may have lost power. This would have affected the results.

## Aspect 3 : Suggests realistic improvements in respect of identified weaknesses with limitations

1. Try to be quantitative in improvements eg. use an ammeter that reads to 0.01A instead of 0.1A.

2. Digital is not always better. Best to state quantitatively the sensitivity as above.

3. 'Measure length digitally', 'Use a better thermometer' 'use more precise equipment', are insufficient for even a 'partial'.

1. Examiners report : “the idea of repeating of readings as an improvement to the experiment is often missed”!

5. If you are commenting on your measurements, write down the one with the largest percentage error and address that.